Staying 3D with HBIM?

A three-dimensional processing of data from large historic building complexes.

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Introduction

In the process of historical building research, a lot of data will be generated in the procedure which must be sorted, interpreted and stored. The same counts for any project of cultural heritage preservation. Doing that with two-dimensional drawings and text documents (eg. with conventional room books) is working quite well and should be continued to be done because of its simple archivability and divisibility. In large historical ensembles with a lot of different information it is difficult or impossible to keep track of the data and extract new information from the data using classic 2D documentation methods. Another downside is in example the readability of this information for non-specialists. Not everyone is able to read and understand a ground plan, especially when it contains lots of detail information. And even many members of the construction industry, such as architects and civil engineers, have never encountered a room book. Also, with technologies like laser scanning and structure-from-motion which can generate precise three-dimensional information about the investigated objects it's always a step back to draw only 2D data from it. Therefore, it's a logically step to try to stick three dimensional in the process of data management as long as possible. Digital 3D models can help to filter and reduce the information and the detail of geometry to an appropriate level. Software with 3D-modeling and building information modelling (BIM) tools can help to achieve that goal. The building information modelling is a further development of computer aided design which slowly transformed from a basic two-dimensional drawing to three dimensional models (Hemmerling, 2010). The 3D models of buildings first were used only for representation of the design but then the models where separated in building components which had their own values and could be related to one another. These building components were then able to possess and generate detailed information. Thereby the building model became a building information model. The whole process was designed for new construction and further development for as-built documentation happens very sluggishly. The still ongoing process of validation to find a procedure to

use BIM for building research has led some knowledge about the usability of historical building information modelling (HBIM) which this paper attempts to illustrate.

Cases and method

In order to make a comprehensive assessment of the applicability of HBIM in historical building research and cultural heritage preservation, several complexes of different building types and conditions are investigated. Therefore, three building complexes with various construction and states of conservation will be modelled and analysed using HBIM in this investigation project. The information that the models will contain must be useful for a wide range of issues. These will include for instance questions of building research, the building process, presentation of findings, building phases, reconstruction, building maintenance, restoration and the use and conversion of historical buildings. The complexes represent a wide range of building phases, construction, deformation and use.

The first case is the ancient 'Villa dei Sette Bassi' built in the 2nd century in the southeast of Rome (Italy). It represents one of the largest suburban villa complexes in the Imperial era of Rome. The villa is a very interesting archaeological site in a rather ruined state. The other two objects of study are a simple two-storey building with basement made of timber frame construction (St. Valentines hospital of Hesse, Germany, late 17th century) and the carpet factory in Wurzen (Germany), a well-preserved building from the beginning of the 20th century made of reinforced concrete.

So far, the modelling process of the ancient villa is the most advanced. Therefore, this abstract will elaborate on the villa complex.

Ancient brick villa complex of the 2nd century

The 'Villa dei Sette Bassi' today covers a site of 3 ha with several building complexes, including thermal baths, an aqueduct line, one cistern, a temple-structure and various other building-structures. The three huge brick constructed main buildings were built in a short period between 130-160 A.D., which the numerous brick stamps indicate. The villa ensemble was supplemented with a huge architectural garden, the so-called Hippodrome (Seiler et al., 2018). The ruined state of the building and the large number of conversions and construction phases pose many challenges. Due to the amount of building structures, the information-modelling is focussed on the main building complexes A and B shown by Fig. 1.

Fig. 1. Drone image of the Sette Bassi villa (viewed from the west) (© Ilka Viehmann). Left: building complex B. Middle: the so-called temple. Right: building complex A.

Method

As the modelling process advances it shows some significant possibilities. The point cloud of complex A (Fig. 2, top right) already captures the geometry of the building in a very high level of accuracy (LOA). The level of accuracy (USIBD, 2019) is a concept to classify how precisely and detailed the surveyed point cloud is. The point cloud represents the as-built state (Fig. 2, top left) in one of the highest LOA. This is why the geometric complexity of the model can be tuned down during the modelling process to a necessary level of detail (LOD) (BIM Forum, 2021). It significantly reduces the workload in the modelling process if it is assumed that geometry is only one of many attributes. In case of the villa it's a simple and plain wall surface, only the edges of the wall will be adjusted (Fig. 2, bottom centre). In the next step the openings and findings will be added to the model. After all the building parts are added all the information about the building can be attached to the relevant parts. This way the principals of a room book are used but the information is processed three-dimensional. Therefore, all the information can be found in the digital model at the exact place you would find them on the real building.

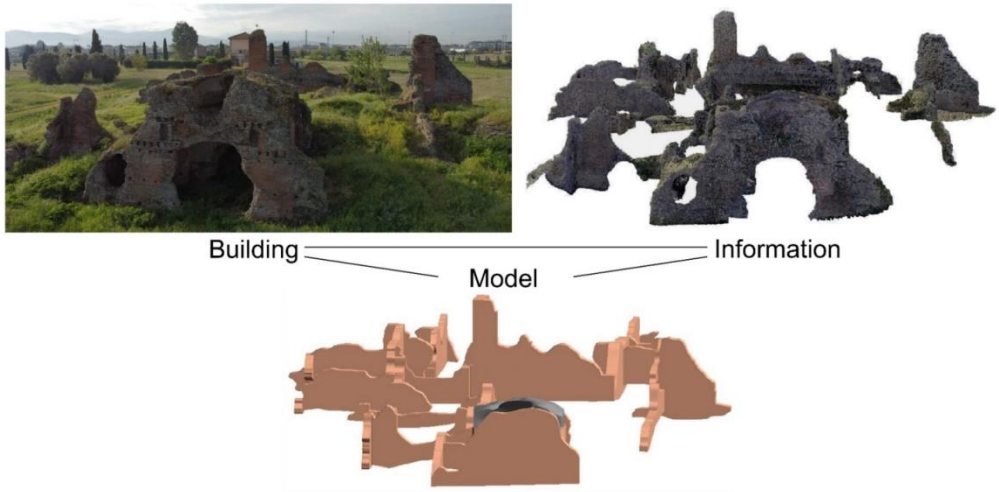

Fig. 2. Reference of building, information and model from complex A of the Sette Bassi villa (© Ilka Viehmann).

Fig. 3. Comparison of reconstruction and existing building remains in Autodesk Revit (© Ilka Viehmann). Left: A reconstruction proposal. Right: Reconstruction and remains in comparison

After modelling the as-built state of the buildings the development of reconstruction proposals can begin. The information model will provide the basis for geometry and design of the reconstruction. After having a simplified "as-built" model and a reconstruction model it is very simple and descriptive to compare the two models as shown in Fig. 3. Also, various reconstruction proposals can be superimposed.

Issues and conclusion

Anytime in the building life-cycle and even after the building is destroyed it is possible to gain information from the point-cloud. Whether questions of building research, maintenance or use of the building are concerned, the point cloud is an excellent source. And there is one big advantage of the point cloud over the model, because it is less prone to the subjective influence of the editors. That's why a point-cloud-based model should always include the possibility of comparison the model and point-cloud.

The biggest issue is still the archivability and the possibility of making the data available to a wide range of users as many previous studies show (Logothetis et al., 2017). For the process a proprietary software is currently used which is very beneficial for the whole point cloud to model workflow but comes with a bunch of difficulties when it involves sharing the data. At the moment some web viewer solutions are tested but it's still a labour-intensive process. Anyways the historical building information modelling provides some very useful tools in managing data and geometry in a three-dimensional fashion.

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